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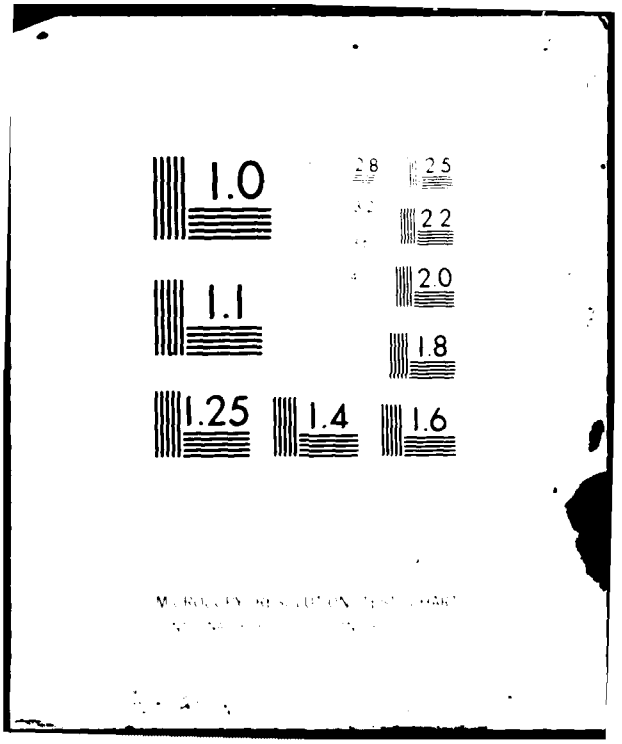
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ANNUAL SUMMARY

OF

MOLECULAR BEAM STUDIES OF LOW ENERGY REACTIONS

ONR CONTRACT NO. N00014-81-K-0255

PRINCIPAL INVESTIGATOR: R. H. NEYNABER

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November 20, 1981

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Chemi-ionization	Cross sections
Ion-molecule reactions	Molecular beams
Charge transfer	Reaction rates

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The annual summary of the research performed under ONR Contract No. N00014-81-K-0255 is given. The report describes merging-beams studies of charge-transfer reactions. Included are investigations of the Cl^{4}-Xe and He^{4}-$He(2^{3}S)$ systems.

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Annual Summary

of

Molecular Beam Studies of Low Energy Reactions
ONR Contract No. N00014-81-K-0255

1. Contract Description

Chemi-ionization and ion-molecule reactions involving metastable and ground-state atoms are studied by merging beams at low relative energies (i.e., 0.01 to 10 or 20 eV).

2. Scientific Problem

Some theories exist for chemi-ionization involving collisions of metastable and ground-state rare gases. There is very little experimental data to test these theories over a range of relative kinetic energy from 0.01 to 10 or 20 eV. We will supply such data. Theoretical work for collisions between two metastables is almost non-existent, and experimental data are scant. We will supply experimental information such as absolute and relative cross sections and branching ratios for associative to Penning ionization. This information should establish patterns to test those calculations that do exist and will stimulate further theory. Our chemi-ionization data also will produce some information on unknown potentials for the systems A^*B and C^*D, where A, B, C, and D are atoms and asterisks denote metastables. This information includes well depths and the dependence of the long range potential on internuclear separation.

The composition of keV neutral rare gas beams formed by charge transfer of the rare gas parent ion beam in alkalis is unknown. The beams consist of rare gas metastables (generally in two states) and ground-state atoms. The technique for generating such beams is common, and information on the composition is needed in analyzing data obtained through their use. We have developed a method for obtaining the fraction of ground-state

atoms in such beams by studying appropriate ion-molecule reactions. We will apply this method to determine unknown compositions.

No experimental information exists on low-energy resonant or near-resonant charge-transfer reactions between rare gas ions and metastables. Our experiments will supply such information. The data can be used to see if existing theories for charge transfer between ions and ground-state atoms can be extended to this case. We also will investigate energy distributions of product ions from which information on the reaction kinetics can be obtained.

Charge-transfer studies of special interest to the Navy will also be conducted.

3. Scientific and Technical Approach

Merging-beams techniques will be used for the studies. The two reactants of the process under investigation will be merged. Their velocities will be adjusted with respect to each other so that the desired relative energy in the center-of-mass system will be obtained. Product ions resulting from the reaction will be collected to give relative and absolute cross sections, and branching ratios will be obtained when appropriate.

4. Progress

A totally new contract was started on 1 March 1981. The progress on this program for a period of 8-1/2 months is discussed below.

a) We analyzed and published our results for the study of the charge-transfer reaction $Cl^+ + Xe \rightarrow Cl + Xe^+$ in the relative energy range of 1-900 eV. The reaction is asymmetric with cross sections increasing with increasing collision energy. At 20 eV the cross section is about 1.9×10^{-16} cm^2.

b) Absolute and relative cross sections were obtained for the charge transfer between ground-state helium ions and helium atoms in the first metastable state. The reaction is $He^+(1\,^2S) + He(2\,^3S) \rightarrow He(2\,^3S) + He^+(1\,^2S)$. Resonant charge transfer (RCT) preceded by capture, or orbiting,

collisons occurs for $W \leq 0.04$ eV, whereas RCT without capture occurs at higher W. Agreement with impact-parameter calculations is fairly good at intermediate W but poor at the higher and lower ranges of W covered in the experiment.

c) A paper on our study of the charge transfer between He^+ and $He(2^3S)$ was presented at the XII International Conference on the Physics of Electronic and Atomic Collisions, Gatlinburg, Tenn., July 15-21, 1981.

5. Publications

The following paper has been published since the new contract was begun on 1 March 1981.

R. H. Neynaber and S. Y. Tang, "Charge Transfer of Cl^+ in Xe," J. Chem. Phys. 75, 2469 (1981).

6. Extenuating Circumstances

None.

7. We do not expect any unspent funds to be remaining at the end of the current contract period.

8. No graduate students or postdoctoral personnel have been associated with the contract.

9. R. H. Neynaber has not been supported by any other Federal grant or contract since the inception of this ONR contract.

February 1981

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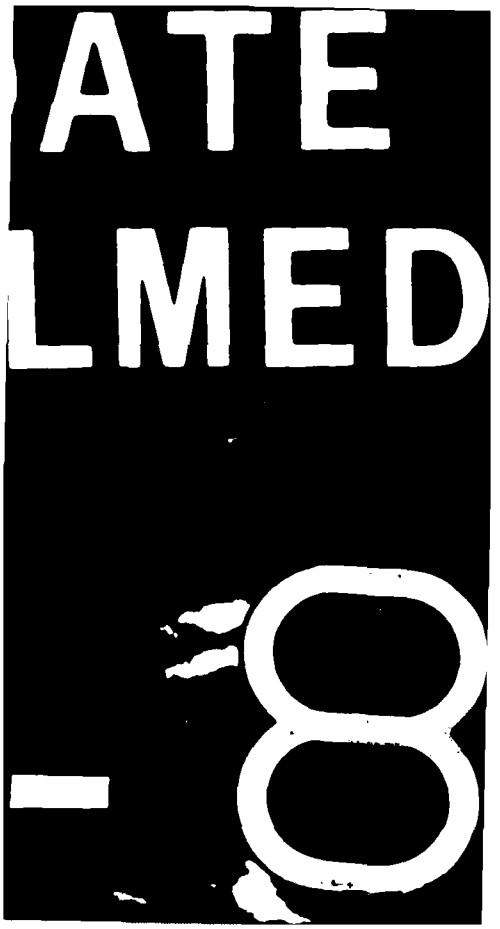
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